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**State of California  
The Resources Agency  
Department of Water Resources**

**MATRIX OF LIFE HISTORY AND  
HABITAT REQUIREMENTS FOR  
FEATHER RIVER FISH SPECIES  
SP-F3.2 TASK 2  
SP-F21 TASK 1**

**PIKEMINNOW**

**Oroville Facilities Relicensing  
FERC Project No. 2100**



**APRIL 2004**

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**State of California  
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Matrix Of Life History and Habitat Requirements for Feather River Fish Species – Pikeminnow  
Oroville Facilities P-2100 Relicensing

Element	Element Descriptor	General	Feather River specific
<b>General</b>			
common name (s)	English name (usually used by fishers and laypeople).	<p>Sacramento squawfish, Sacramento pikeminnow</p> <p>The name “pikeminnow” was adopted in 1998 by the American Fisheries Society to replace “squawfish”, which is considered derogatory to Native Americans (Moyle 2002).</p>	
scientific name (s)	Latin name (referenced in scientific publications).	The scientific name for Sacramento pikeminnow is <i>Ptychocheilus grandis</i> .	
taxonomy (family)	Common name of the family to which they belong. Also indicate scientific family name.	Minnows are in the family <i>Cyprinidae</i> .	
depiction	Illustration, drawing or photograph.		
range	Broad geographic distribution, specifying California distribution, as available.	<p>Sacramento pikeminnow were historically distributed throughout the Sacramento and San Joaquin river systems (Grant and Maslin 1999).</p> <p>Sacramento pikeminnow inhabit low to middle elevation waters in the Sacramento and San Joaquin river basins and are common in tributaries on the western slope of the Sierra Nevada Mountains (Grant and Maslin 1999).</p> <p>Sacramento pikeminnow also are found in the Pajaro and Salinas rivers, Russian River, Clear Lake basin, and upper Pit River (Moyle 2002).</p> <p>Sacramento pikeminnow were introduced into the Eel River in northwestern California in 1980 (Harvey et al. 2002).</p> <p>Sacramento pikeminnow are found primarily in the Sacramento and San Joaquin river basins, Russian</p>	

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		River, and Pajaro-Salinas river drainages of central California (Brown and Moyle 1981).	
native or introduced	If introduced, indicate timing, location, and methods.	Sacramento pikeminnow are native to the Feather River.	
ESA listing status	Following the categories according to California Code of Regulations and the Federal Register, indicate whether: SE = State-listed Endangered; ST =State-listed Threatened; FE = Federally listed Endangered; FT = Federally-listed Threatened; SCE = State Candidate (Endangered); SCT = State candidate (Threatened); FPE = Federally proposed (Endangered); FPT = Federally proposed (Threatened); FPD = Federally proposed (Delisting); the date of listing; or N = not listed.	Sacramento pikeminnow are not a listed species (DFG 2002).	
species status	If native, whether: Extinct/extirpated; Threatened or Endangered; Special concern; Watch list; Stable or increasing. If introduced, whether: Extirpated (failed introduction); highly localized; Localized; Widespread and stable; Widespread and expanding.	<p>Sacramento pikeminnow are a native species with a stable or increasing population (Moyle 2002).</p> <p>Sacramento pikeminnow are reportedly less abundant now, relative to historical population levels, in lowland habitats, where they used to be dominant predators. Sacramento pikeminnow have maintained large populations in the Sacramento River, foothill streams, and many regulated streams. Large reservoirs, created by damming Central Valley tributaries, have been colonized by Sacramento pikeminnow in large numbers. In large hydropower reservoirs, which operate like giant riverine pools and are not drawn annually, large populations of Sacramento pikeminnow are maintained (Moyle 2002).</p>	
economic or recreational value	Indicate whether target species sought for food or trophy. Whether desirable by recreational fishers, commercial fishers, or both.	Sacramento pikeminnow have not been commonly used for food by fishermen, although Indian middens contain bones of this species (Wang 1986).	
warmwater or	Warmwater if suitable temperature	Sacramento pikeminnow prefer warmwater (Moyle 2002).	

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coldwater	range is similar to basses; coldwater if suitable temperature range is similar to salmonids.		
pelagic or littoral	Environment: Pelagic - living far from shore; Littoral - living near the shore.		
bottom or water column distribution	Environment: bottom (benthic) or along water column.	Sacramento pikeminnow reportedly inhabit mid-depth and surface waters (Cooper 1983).  Sacramento pikeminnow normally occupy the middle of the water column in pools and runs (Baltz et al. 1987).	
lentic or lotic	Environment: Lentic - pertaining to stagnant water, or lake-like; Lotic - moving water, or river-like.	Sacramento pikeminnow are lotic in the Eel River (Brown and Moyle 1997).	
<b>Adults</b>			
life span	Approximate maximum age obtained.	Sacramento pikeminnow measuring 26 inches (66 cm) SL from the Russian River have been reportedly aged, using opercular bones, at 16 years (Moyle 2002).  Using scales, Sacramento pikeminnow have been reportedly aged up to 12 years, although this method is considered unreliable for determining the age of older fish (Moyle 2002).  Sacramento pikeminnow can reportedly live up to 9 years, and mature in their third or fourth year (in summer) (Wang 1986).	
adult length	Indicate: Length at which they first reproduce; average length and maximum length the fish can attain.	Sacramento pikeminnow are typically 8.7–9.8 inches (22-25 cm) SL at sexual maturity (Moyle 2002).  The reported average length of age 4 Sacramento pikeminnow harvested in Bear Creek (Colusa County, California) was 10.12 inches (257 mm) SL (Brown 1990).  The largest reported Sacramento pikeminnow was 45.3 inches (115 cm) TL (Wang 1986).  Sacramento pikeminnow can potentially be over 3.3 ft (1 m) TL (Moyle 2002).	

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		Sacramento pikeminnow reportedly reach 2.0–3.3 inches (50–85 mm) SL at the end of the first year, 3.9–5.9 inches (100–150 mm) SL at the end of the second year, 6.7–9.8 inches (170–250 mm) SL at the end of the third year, 9.4–10.6 inches (240–270 mm) SL at the end of the fourth year, and 10.2–13.8 inches (260–350 mm) SL at the end of the fifth year (Moyle 2002).	
adult weight	Indicate: Weight at which they first reproduce; average weight and maximum weight the fish can attain.	The largest reported Sacramento pikeminnow on record weighed 32 lbs. (14.5 kg) (Wang 1986).  Sacramento pikeminnow reportedly weigh from 0.25 lb. to 5 lbs. (0.11–2.3 kg) (Bell 1991).	
physical morphology	General shape of the fish: elongated, fusiform, laterally compressed, etc.	Sacramento pikeminnow have an elongated body, flattened and tapered head, and deeply forked tail (Moyle 2002).	
coloration	Indicate color, and color changes, if any, during reproduction phase.	Large Sacramento pikeminnow are generally a dark brownish- olive on the back and gold-yellow ventrally. Small Sacramento pikeminnow are silvery on all sides with a dark spot at the base of the tail. Fins of breeding adults are tinged with reddish orange (Moyle 2002).  Several weeks before spawning the Sacramento pikeminnow in Pine Creek developed a dark lateral band (Grant and Maslin 1999).	
other physical adult descriptors	Unique physical features for easy identification.	Sacramento pikeminnow have a large mouth with the maxilla extending behind the front margin of the eye (Moyle 2002).	
adult food base	Indicate primary diet components.	Adult Sacramento pikeminnow feed on juvenile anadromous salmonids (Beamesderfer et al. 1996).  Sacramento pikeminnow larger than 7.9 inches (>200 mm) SL feed primarily on fish, taking other prey such as frogs and crayfish when available (Grant and Maslin 1999).  In the Eel River, Sacramento pikeminnow forage on emigrating juvenile salmon during spring months (Moyle 2002).	

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		<p>Sculpin are the most common prey of Sacramento pikeminnow greater than 9.8 inches (&gt;250 mm) SL in the Eel River (White and Harvey 2001).</p> <p>An Eel River study demonstrated that Sacramento pikeminnow had a severe negative effect on the abundance of sculpin (White and Harvey 2001).</p> <p>Sacramento pikeminnow feed on small salmon, especially those released from hatcheries (Patten and Rodman 1969).</p>	
adult feeding habits	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder.	<p>Sacramento pikeminnow in the Eel River forage at night in runs and shallow riffles to feed on small fish (Moyle 2002).</p> <p>A study done in the Columbia River system demonstrated that pikeminnow feed most heavily at dusk and dawn, but full stomachs can be found throughout the day and night (Brown and Moyle 1981).</p>	
adult in-ocean residence time	For anadromous species, age when they migrate to the ocean and duration spent in the ocean before returning to freshwater to spawn.		
adult habitat characteristics in-ocean	For anadromous species, description of the ocean habitat utilized: whether along major current systems, gyres, pelagic (beyond continental shelves) and neritic (above continental shelves) zones, etc.		
<b>Adult upstream migration (immigration)</b>			
range of adult upstream migration timing	Time of year adults migrate upstream. If applicable, indicate for various runs.		
peak adult upstream migration timing	Time of year most adults migrate upstream. If applicable, indicate for various runs.		
adult upstream	Range of water temperatures		

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migration water temperature tolerance	allowing survival. Indicate stressful or lethal levels.		
adult upstream migration water temperature preference	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.		
<b>Adult holding (freshwater residence)</b>			
water temperature tolerance for holding adults	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	<p>In the Pit River in Shasta County, Sacramento, Sacramento pikeminnow were reportedly observed in water temperatures of 35.6°F to 68°F (2°–20°C) (Baltz et al. 1987).</p> <p>In the Sacramento-San Joaquin river systems, the reported maximum preferred temperature for Sacramento pikeminnow is approximately 78.8°F (26°C). Water temperatures above 100.4°F (38°C) are reportedly lethal to Sacramento pikeminnow (Moyle 2002).</p> <p>The reported optimum temperature range for Sacramento pikeminnow is 61°F–76°F (16.1°C–24.4°C) with an upper lethal water temperature of 85°F (29.4°C) (Bell 1991).</p>	
water temperature preference for holding adults	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.		
water depth range for holding adults	Reported range of observed (minimum and maximum) water depth utilization.	<p>In the Eel River, Sacramento pikeminnow were observed at depths of 17.3–45.3 ft (44–115 cm) (Brown and Moyle 1991).</p> <p>In Eel River tributaries, Sacramento pikeminnow were observed at depths of 3.5–17.7 inches (9 to 45 cm) (Harvey et al. 2002).</p>	
water depth preference for holding adults	Reported range of most frequently observed water depth utilization.	In the Eel River, the average water depth in which adult and juvenile Sacramento pikeminnow were found was 47.2 inches (120 cm) and 18.5 inches (47 cm), respectively. In the Van Duzen River, the average water	

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		<p>depth in which adult pikeminnow were found was 45.3 inches (115 cm) in pools and 17.1 inches (45 cm) in combined riffle and run habitats. Juvenile Sacramento pikeminnow in the Van Duzen River were observed in average water depths of 17.3 inches (44 cm) in pools and 14.2 inches (36 cm) in riffle/run habitats (Brown and Moyle 1991).</p> <p>In the Pit River, Sacramento pikeminnow were observed in mean water depths of 27.3 to 35.0 inches (69.4–88.8 cm), with mean focal point elevations (i.e., distance above bottom) of 4.9 to 15.5 inches (12.5–39.3 cm) (Baltz et al. 1987).</p> <p>Models developed based on habitat use within Eel River tributaries indicate that depth alone explains less than 1% of the variation in age-0 Sacramento pikeminnow abundance (Harvey et al. 2002).</p>	
substrate preference for holding adults	If bottom dwellers, indicate substrate: mud, sand, gravel, boulders, aquatic plant beds, etc. If gravel, indicate range or average size of gravel.	Within the Eel River tributaries, Sacramento pikeminnow were observed over gravel or finer substrates (Harvey et al. 2002).	
water velocity range for holding adults	Reported range of observed (minimum and maximum) water velocity utilization.	<p>Sacramento pikeminnow were reportedly observed at 0.1–1.01 ft/sec (3–31 cm/sec) in the Eel River (Brown and Moyle 1991).</p> <p>Sacramento pikeminnow were reportedly observed at mean surface velocities of 0.73–0.91 ft/sec (22.2–27.8 cm/sec) in the Pit River (Baltz et al. 1987).</p>	
water velocity preference for holding adults	Reported range of most frequently observed water velocity utilization.		
other habitat characteristics for holding adults	General description of habitat (e.g. turbid or clear waters, lentic or lotic, presence of aquatic plant beds, debris, cover, etc.).	<p>In the Eel River tributaries, Sacramento pikeminnow utilize large channels with low gradients and warm water temperatures (Harvey et al. 2002).</p> <p>Sacramento pikeminnow utilize riffles within the Pit River and its tributaries (Cooper 1983).</p>	

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		A study conducted in the Sacramento-San Joaquin river drainage showed that Sacramento pikeminnow were uncommon at low elevations, where they once occurred in large numbers, and were most abundant in the larger intermittent and permanent streams at elevations from 656.2–1,640.4 ft (200–500 m) (Moyle and Nichols 1974).	
timing range for adult holding	Time of year (earliest-latest) and duration of stay from upstream migration to spawning.		
timing peak for adult holding	Time of year when maximum number of adults are present before spawning.		
<b>Spawning</b>			
fecundity	Average or range in the number of eggs females lay in a spawning season.	<p>Fecundity in Sacramento pikeminnow ranges from 15,200 to 21,600 eggs per female (Grant and Maslin 1999).</p> <p>Female Sacramento pikeminnow reportedly range between 12.2 to 25.6 inches (31–65 cm) SL in size and contain 15,000 – 40,000 eggs (Moyle 2002).</p> <p>Sacramento pikeminnow reportedly produce between 5,000 and 20,000 eggs per female (Bell 1991).</p>	
nest construction	Location and general description of nest -- substrates, aquatic plants, excavations, crevices, habitat types, etc.	<p>Sacramento pikeminnow observed in Suisun Creek and Sonoma Creek, usually constructed nests downstream of a pool with running water (Wang 1986).</p> <p>Sacramento pikeminnow eggs apparently are randomly deposited over gravel beds (American Fisheries Society 2000).</p>	
nest size	Size and average dimensions of the nest.		
spawning process	Indicate whether nest builder, broadcast spawner, or other.	Pursued by 1-6 males, the female Sacramento pikeminnow dips close to the bottom and releases a small quantity of eggs, which are simultaneously fertilized by a male Sacramento pikeminnow. The fertilized Sacramento pikeminnow eggs sink to the bottom and adhere to rocks and gravel (observed in Merwin Reservoir) (Moyle 2002).	

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		<p>Congregating northern pikeminnow in the lower Columbia River drainage exhibited spawning behavior consisting of “swarming” and “chasing”, which culminated in the spawning act (Patten and Rodman 1969).</p> <p>Observations in the Sacramento-San Joaquin river drainage indicate that Sacramento pikeminnow spawn primarily at night (Moyle 2002).</p> <p>The spawning process is thought to be similar to that of other native cyprinids and the northern pikeminnow (Moyle 2002).</p>	
spawning substrate size/characteristics	Range of substrates used during spawning (e.g. mud, sand, gravel, boulders, beds of aquatic plants). Indicate presence of plant/wood debris, crevices at spawning sites. If gravel, indicate range of average size.	<p>In the Sacramento and San Joaquin river drainages, Sacramento pikeminnow utilize areas with rocks and gravel (Wang 1986).</p> <p>At Merwin Reservoir, the northern pikeminnow spawning area was reportedly characterized by steep talus slopes of shale rocks [5.9–7.9 inches (15 to 20 cm) in diameter] (Patten and Rodman 1969).</p> <p>Northern pikeminnow in Idaho lakes were observed spawning over rocks 2.0 to 9.8 inches (5 to 25 cm) in diameter (Patten and Rodman 1969).</p>	
preferred spawning substrate	Indicate preferred spawning substrate (e.g. mud, sand, gravel, boulders, plant bed, etc).	<p>Within the Sacramento River system, the preferred spawning substrate(s) habitat are gravel riffles or shallow flowing areas at the base of the pools for Sacramento pikeminnow (Moyle 2002).</p> <p>In the Sacramento-San Joaquin river system, Sacramento pikeminnow spawning was observed in gravel riffles (Wang 1986).</p>	
water temperature tolerance for spawning	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	In the Sacramento-San Joaquin river systems, the reported maximum preferred temperature for Sacramento pikeminnow is approximately 78.8°F (26°C). Water temperatures above 100.4°F (38°C) are reportedly lethal to Sacramento pikeminnow (Moyle 2002).	

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		The reported upper lethal water temperature for Sacramento pikeminnow is 85°F (29.4°C) (Bell 1991).	
water temperature preference for spawning	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	<p>Sacramento pikeminnow spawning was observed at water temperatures of 56°F to 62.6°F (13.3°C to 17°C) within the Eel River drainage (Harvey et al. 2002).</p> <p>Pikeminnow in Pine Creek were observed spawning in water temperatures of 53.6°F to 68°F (12°C to 20°C) (Grant and Maslin 1999).</p> <p>Sacramento pikeminnow males typically arrive to spawning areas when water temperatures reach 59°F – 68°F (before female arrival) (15°C–20°C) (Moyle 2002).</p> <p>Sacramento pikeminnow were observed spawning in water temperatures greater than 57.2°F (&gt;14°C) in tributaries of the Sacramento-San Joaquin River system (Wang 1986).</p> <p>The average water temperature during pikeminnow spawning in Merwin Reservoir was 62.5°F (17°C) (Patten and Rodman 1969).</p> <p>Sacramento pikeminnow reproduced in the largest, warmest tributaries within the Eel River drainage (Harvey et al. 2002).</p>	
water velocity range for spawning	Minimum and maximum speed of water current the spawning fish can tolerate.		
water velocity preference for spawning	Preferred water current (flow velocity) during spawning.	<p>Sacramento pikeminnow spawn in gravel riffles or shallow flowing areas at the base of pools (Moyle 2002).</p> <p>Calm water conditions prevailed during the period of pikeminnow spawning in Merwin Reservoir (Patten and Rodman 1969).</p> <p>Within the Monticello Reservoir basin, Sacramento pikeminnow in streams were reported to migrate upstream for spawning during high flows (Grant and</p>	

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Element	Element Descriptor	General	Feather River specific
		Maslin 1999).	
water depth range for spawning	Reported range of observed (minimum and maximum) water depth utilization.	Within Merwin Reservoir, pikeminnow spawning occurred at a depth below 1.2 inches (3 cm), and the maximum depth was determined by the thermocline (Patten and Rodman 1969).	
water depth preference for spawning	Reported range of most frequently observed water depth utilization.	Pikeminnow were observed spawning in Merwin Reservoir at a depth range of 3.0–7.9 inches (5 cm to 20 cm) (Patten and Rodman 1969).  Sacramento pikeminnow spawn in gravel riffles or shallow flowing areas at the base of pools (Moyle 2002).	
range for spawning timing	Earliest and latest time of season or year in which spawning occurs.	In the Eel River drainage, Sacramento pikeminnow spawning occurs from May through June (Harvey et al. 2002).  In the Sacramento-San Joaquin river system, Sacramento pikeminnow spawning occurs from April through July (Wang 1986).  In Pine Creek, Sacramento pikeminnow spawning occurred between mid-April and early May (Grant and Maslin 1999).	
peak spawning timing	Time of year most fish start to spawn.	Fecund Sacramento pikeminnow move to spawning areas during April and May (Moyle 2002).  In Pine Creek, most spawning reportedly occurred by May 3 (Grant and Maslin 1999).  In Merwin Reservoir, northern pikeminnow spawning extended through June and July, but was most active during the first part of July (Wang 1986).	
spawning frequency (iteroparous/semelparous)	Semelparous - producing all offspring at one time, such as in most salmon. Usually these fish die after reproduction. Iteroparous - producing offspring in successive, e.g., annual or seasonal batches, as is the case in most fishes.	Sacramento pikeminnow are iteroparous. Sacramento pikeminnow spawn annually, but only when conditions are favorable (Moyle 2002).	

**Incubation/early development**

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Element	Element Descriptor	General	Feather River specific
egg characteristics	Shape, size, color, in clusters or individuals, stickiness, and other physical attributes.	Mature Sacramento pikeminnow eggs are reportedly adhesive and spherical, measuring 0.86–0.94 inches (22–24 mm) in diameter (Wang 1986).	
water temperature tolerance for incubation	Range of water temperatures allowing survival. Indicate stressful or lethal levels.		
water temperature preference for incubation	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	Northern pikeminnow eggs will reportedly hatch when reared at 64.4°F (18°C); suitable water temperatures are likely to be similar for Sacramento pikeminnow (Moyle 2002).  Northern pikeminnow eggs are incubated under laboratory conditions at water temperatures of 59°F–62.6°F (15°C to 17°C) (Gadomski et al. 2001).	
time required for incubation	Time duration from fertilization to hatching. Note: Indicate at which temperature range. Incubation time is temperature-dependent.	Northern pikeminnow eggs reportedly hatch in 4-7 days at 64.4°F (18°C). Fry begin shoaling in another 7 days (Moyle 2002).  Laboratory reared northern pikeminnow eggs have been reported to hatch in 8-10 days at 59°F–62.6°F (15°C to 17°C) (Gadomski et al. 2001).  Pikeminnow eggs are reported to hatch in 7 days at 65°F (18.3°C) (Bell 1991).	
size of newly hatched larvae	Average size of newly hatched larvae.	Sacramento pikeminnow larvae reportedly range from 0.38 to 0.5 inches (9.7–12.5 mm) TL (Wang 1986).	
time newly hatched larvae remain in gravel	Time of year of hatching, and duration between hatching and emergence from gravel.	Newly hatched Sacramento pikeminnow larvae remain in crevices of the nesting area for a short period until the yolk sac is absorbed (Wang 1986).	
other characteristics of larvae	Alevin -- early life history phase just after hatching (larva) when yolk-sac still present.		
timing range for emergence	Time of year (earliest-latest) hatchlings (larvae and alevins) leave or emerge from the nesting/hatching (gravel) sites.		
timing peak for emergence	Time of year most hatchlings emerge.		

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size at emergence from gravel	Average size of hatchlings at time of emergence.	At the completion of the yolk-sac stage, Sacramento pikeminnow are reportedly from 0.33 to 0.35 inches (8.5–9 mm) (Wang 1986).	
<b>Juvenile rearing</b>			
general rearing habitat and strategies	General description of freshwater environment and rearing behavior.	Soon after spawning occurs, shoals of Sacramento pikeminnow larvae or post-larvae can be observed in shallow pool edges or backwaters, often in association with larvae of other native fishes. As the small Sacramento pikeminnow become more active swimmers, they enter deeper water, especially in runs and along riffles associated with cover. Juvenile Sacramento pikeminnow can disperse widely in their first year of life, colonizing stream reaches that have been dried up by drought or made available to them through introductions. Young-of-year typically disperse downstream, whereas yearlings are more likely to move upstream (Moyle 2002).	
water temperature tolerance for juvenile rearing	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Juvenile Sacramento pikeminnow in Eel River tributaries were sampled at maximum weekly average water temperatures of 63.9°F–76.1°F (17.7°C–24.5°C) (Harvey et al. 2002).	
water temperature preference for juvenile rearing	Range of suitable, preferred, or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	Age-0 Sacramento pikeminnow were particularly abundant in the warmest tributaries to the Eel River (Harvey et al. 2002).	
water velocity ranges for rearing juveniles	Reported range of observed (minimum and maximum) water velocity utilization.	Juvenile Sacramento pikeminnow were observed in mean water column velocities of 0.36 ft/sec (11 cm/sec) and 0.03–0.33 ft/sec (1–10 cm/sec) within the Van Duzen River (Brown and Moyle 1991).  Juvenile Sacramento pikeminnow were observed in flows of 0.35–9.5 cfs (0.01–0.27 m <sup>3</sup> /sec) in Eel River tributaries (Harvey et al. 2002).	
water velocities preferred by rearing juveniles	Reported range of most frequently observed water velocity utilization.		
water depth range for juvenile rearing	Reported range of observed (minimum and maximum) water depth utilization.		

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Element	Element Descriptor	General	Feather River specific
water depth preference for juvenile rearing	Reported range of most frequently observed water depth utilization.	Mean water depths in Eel River tributaries, where juvenile Sacramento pikeminnow were sampled, reportedly ranged from 3.45 to 17.7 inches (9–45 cm) and averaged 11 inches (28 cm) (Harvey et al. 2002).	
cover preferences for rearing juveniles	Type of cover for protection from predators used by rearing juveniles (e.g. crevices, submerged aquatic vegetation, overhanging vegetation, substrate cover, undercover bank, small woody debris, large woody debris).	<p>Juvenile Sacramento pikeminnow were observed most often using pools in the Van Duzen River (Brown and Moyle 1991).</p> <p>Various studies have shown that cyprinid larvae prefer shallow, low velocity, vegetated habitats (Gadomski et al. 2001).</p> <p>Wetted areas of Eel River tributaries provided cover for juvenile Sacramento pikeminnow (Harvey et al. 2002).</p>	
food base of juveniles	Indicate primary diet components. Also indicate the diet changes, if any, as growth occurs.	<p>In the lower American River, in which flows are regulated, juvenile Sacramento pikeminnow reportedly feed on small aquatic insects, especially corixids (water boatmen) and chironomid midge larvae; they also feed on larval suckers when they are abundant (Moyle 2002).</p> <p>Sacramento pikeminnow under 3.9 inches (10 cm) SL reportedly feed on aquatic insects, switching to fish and crayfish between 3.9 and 7.9 inches (10 and 20 cm) SL (Moyle 2002).</p> <p>In tributaries, Sacramento pikeminnow juveniles take insect larvae, small insects, small minnows, and salmonid juveniles. Estuarine juveniles feed on small striped bass and splittail, in addition to crustaceans (Wang 1986).</p>	
feeding habits of rearing juveniles	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder. Also indicate change of feeding habits growth occurs.	<p>As observed in the Sacramento River system, juvenile Sacramento pikeminnow forage actively during the day, with peak feeding occurring in the early morning (Moyle 2002).</p> <p>Sacramento pikeminnow are opportunists, taking prey on the bottom, at the surface, or in between, depending on type, abundance, and time of day (Moyle 2002).</p>	
predation of juveniles	Indicate which species prey on juveniles.	Juvenile Sacramento pikeminnow are prey of herons in shallow water and other fish species in deeper water	

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Matrix Of Life History and Habitat Requirements for Feather River Fish Species – Pikeminnow  
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Element	Element Descriptor	General	Feather River specific
		(Moyle 2002).	
timing range for juvenile rearing	Range of time of year (months) during which rearing occurs.	Studies within the San Joaquin River drainage showed that juvenile Sacramento pikeminnow inhabited streams until October or November, then migrated into deeper portions of large water bodies (Wang 1986).  Juvenile Sacramento pikeminnow may enter Eel River tributaries most frequently in late summer (May-June) (Harvey et al. 2002).	
timing peak for juvenile rearing	Time of year (months) during which most rearing occurs.		
<b>Juvenile emigration</b>			
time spent in fresh water prior to emigrating	Duration (in years and/or months) from emergence to emigration to the ocean.		
water temperature tolerances during emigration	Range of water temperatures allowing survival. Indicate stressful or lethal levels.		
water temperature preferences during emigration	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.		
emigration timing range	Time of year juveniles commence emigration and duration of emigration.		
emigration timing peak	Time of year most juveniles are emigrating.		
size range of juveniles during emigration	Minimum and maximum sizes (inches or mm) of emigrating juveniles. Indicate average size.		
factors associated with emigration	Pulse flows, water temperature changes, turbidity levels, photoperiod, etc.		
<b>Other potential factors</b>			
DO	Levels of DO in water expressed in mg/L tolerated by fish.		
pH	Alkalinity/acidity of water (expressed		

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Element	Element Descriptor	General	Feather River specific
	in pH) that fish can tolerate.		
turbidity	Indicate turbidity or state of water (e.g., clear water or presence of siltation or organic/inorganic matter in water) that fish can tolerate.	Sacramento pikeminnow are largely absent from highly turbid habitats (Moyle 2002).	
factors contributing to mortality	e.g. fishing/angling mortality, drastic habitat alterations, unfavorable climatic changes, etc.	Factors affecting Sacramento pikeminnow populations include the introduction of nonnative species (competitors) and alteration of river systems (e.g., construction of dams and reduced stream flows due to diversions) (Grant and Maslin 1999).	
<b>Predation-related characteristics</b>			
consumption rates by size	Rate of consumption of prey by predator size.		
consumption rates by lifestage	Rate of consumption of prey by predator lifestage.	<p>Consumption of juvenile salmonids by northern pikeminnow was measured at two locations in the Columbia River system. In the McNary Dam tailrace, consumption rates between April and August of 1983 through 1988 were 0.139-2.027/prey/predator/day, and in the John Day Reservoir pool, consumption rates were 0.043-0.251 prey/predator/day (Vigg et al. 1991).</p> <p>At John Day Reservoir the daily consumption ratio for northern pikeminnow over 17.76 inches (451 mm FL) is greater than 13.2 mg consumption prey/g predator/day . Salmonids compose an increasing proportion of the total ratio as the pikeminnow grows (Vigg et al. 1991).</p> <p>Consumption rates of northern pikeminnow in the Columbia River system near dams follow classical functional response models – increasing consumption rates with increasing prey densities up to satiation levels (NOAA 2000).</p>	
consumption rates by water temperature	Rate of consumption of prey by water temperature.	Northern pikeminnow have rapid digestion rates. Fish held in cages in their natural habitats (in Griffen and Cultus lakes) digested fish at a rate of 14%/hr at temperatures 50°F–53.6°F (10°C–12°C). Digestive rates increased with increasing temperatures. In water temperatures of 39.2°F–42.8°F (4°C–6°C) digestion rates were 5%/hr and at 75.2°F (24°C) digestion rates were 40-	

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Element	Element Descriptor	General	Feather River specific
		<p>50%/hr. These results indicate that at higher temperatures, pikeminnow feed more heavily and frequently (Brown and Moyle 1981).</p> <p>In the Columbia River system, the highest pikeminnow consumption rates occurred in July, concurrent with maximum water temperatures and maximum abundance of juvenile salmon (Vigg et al. 1991).</p>	
growth rate	Rate at which growth occurs.	Sacramento pikeminnow growth rates tend to be lowest in small streams and fastest in large, warm rivers. Sacramento pikeminnow growth rates in the lower Sacramento River are 1.2-1.5 times higher than growth rates elsewhere (Moyle 2002).	
community interactions (predators)	Known predators.	Juvenile Sacramento pikeminnow are prey of herons in shallow water and other fish species in deeper water (Moyle 2002).	
community interactions (prey)	Known prey.	Sacramento pikeminnow are known to feed on small aquatic insects, corixids, chironomid midge larvae, crayfish, smaller pikeminnow, lamprey ammocoetes, California roach, Sacramento sucker, rainbow trout, threespine stickleback, Chinook salmon, sculpin (Moyle 2002).	
community interactions (competitors)	Known competitors.	<p>Sacramento pikeminnow are competitor with salmonids. Sacramento pikeminnow have gained a reputation in the western United States as both predators and competitors of salmon and trout. However, through an examination of the available literature, it was concluded that there was little evidence of an impact of Sacramento pikeminnow predation on the number of returning salmon. Sacramento pikeminnow do not appear to be significant predators of salmon and trout except under highly localized or unusual circumstances, such as dams and diversions that create habitat more favorable to Sacramento pikeminnow, and poorly planned releases of hatchery smolts (Brown and Moyle 1981).</p> <p>Survival of salmonids is weakly affected by changes in Sacramento pikeminnow distribution, changes in Sacramento pikeminnow consumption rate near the</p>	

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Element	Element Descriptor	General	Feather River specific
		upstream dam (McNary Dam), residence time, or flow (Beamesderfer et al. 1990).	
predator diet by size	Diet of fish by size classes.	<p>In the Central Valley, Sacramento pikeminnow are at the top of the aquatic food chain. Sacramento pikeminnow under 3.9 inches (10 cm) SL feed predominantly on aquatic insects. At 3.9–7.9 inches (10–20 cm) SL, Sacramento pikeminnow switch to fish and crayfish (Moyle 2002).</p> <p>Based on laboratory studies using northern pikeminnow from the Columbia River, a pikeminnow consumption model was developed. This model predicts that a 300-349 mm FL northern pikeminnow could eat seven to eight 0.25–0.28 ounces (7-8 g) meals per day at 50°F (10°C), whereas models derived from previous laboratory studies would predict that the same fish would consume less than one 0.28 ounce (8 g) meal per day (Beyer et al. 1988).</p> <p>In the Eel River, large Sacramento pikeminnow prey on lamprey ammocoetes (Moyle 2002).</p> <p>In free-flowing sections of the Willamette River in Oregon, 75% of pikeminnow over 11.8 inches (30 cm) FL prey on salmonids during outmigration, indicating that only a portion of the population may pose a threat to salmonids (Brown and Moyle 1981).</p> <p>Large Sacramento pikeminnow are documented to prey on California roach, Sacramento sucker and rainbow trout (Moyle 2002).</p> <p>In Bear Creek, smaller Sacramento pikeminnow as a group consumed a wider variety of items than larger Sacramento pikeminnow, but individuals tended to consume only one or two food types at a particular time (Brown 1990).</p> <p>In the Eel River and below Red Bluff Diversion Dam on the Sacramento River, large Sacramento pikeminnow forage on outmigrating juvenile salmonids during spring</p>	

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Matrix Of Life History and Habitat Requirements for Feather River Fish Species – Pikeminnow  
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Element	Element Descriptor	General	Feather River specific
		(Moyle 2002).  For northern pikeminnow 7.1 inches (18 cm) FL, fish and crayfish account for more than 50% of their diet. In the Columbia River, fish and crayfish become an important component of the diet for pikeminnow 9.1–9.8 inches (23–25 cm) FL. (Brown and Moyle 1981).	
predator diet by age group	Diet of fish by age group.	In the lower American River, juvenile Sacramento pikeminnow feed on small aquatic insects, corixids, chironomid midge larvae, and larval suckers. Fish larger than 7.9 inches (20 cm) SL feed exclusively on fish and crayfish. In smaller streams, they cannibalize younger Sacramento pikeminnow (Moyle 2002).	
association of predators to physical facilities including habitat conditions created by operations	Habitat conditions created by operations that are conducive to predation (velocities, temperatures).	At Red Bluff Diversion Dam, nighttime predation rates of Sacramento pikeminnow were enhanced when lights on the dam were turned on, apparently making prey more visible (Moyle 2002).	
association of predators to physical facilities including instream flow obstructions/diversions	Instream flow obstructions and/or diversions associated with structures and facilities that are conducive to predation.	In large hydropower reservoirs, which behave like giant riverine pools and are not drawn down annually, large populations of Sacramento pikeminnow are maintained (Moyle 2002).	
association of predators to physical facilities including unusual flow and/or water temperature patterns	Flow or water temperature associated with structures, or operations facilities that are conducive to predation.	At Red Bluff Diversion Dam, heavy predation on salmon occurs when dam gates are closed, aggregating Sacramento pikeminnow and confusing or injuring small salmon in turbulent flows (Brown and Moyle 1981; Moyle 2002).  Habitat alterations, such as channelization, removal of riparian vegetation, and impoundments, tend to raise water temperatures and lower dissolved oxygen levels, creating conditions more likely to favor Sacramento pikeminnow than salmonids (Brown and Moyle 1981).  High flows and increased turbidity decrease Sacramento	

Element	Element Descriptor	General	Feather River specific
		<p>pikeminnow predation rates on migrating smolts (Brown and Moyle 1981).</p> <p>In the Columbia River system, the predation rate of northern pikeminnow on salmonids is higher in specific locations such as dams, forebays, and tailraces than in pools (NOAA 2000)</p> <p>In high velocity, free-flowing water in the Columbia River system, the pikeminnow switches its diet to benthic prey (Tabor et al. 1993).</p>	

Note: Of the four species of pikeminnows, the northern pikeminnow (*P. oregonensis*) is the most studied. Because the Sacramento pikeminnow appears to be very similar to the northern pikeminnow ecologically, observations on the latter are applicable to Sacramento pikeminnow (Brown and Moyle 1981).

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